# Understanding Crop Response to Phosphorus

**By Paul E. Fixen**

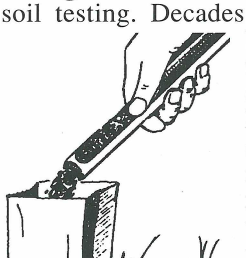
*For profitable crop production, it is crucial to assure that phosphorus (P) nutrition is not limiting yield. In the U.S. and Canada, P is second only to nitrogen (N) as a nutrient limiting crop yield potential.*

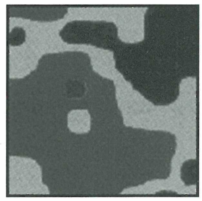
**IN THE FALL** of 1985, a 370 bu/A grain yield was harvested by a master corn grower, Herman Warsaw of Saybrook, IL. Field average corn yields frequently soared to over 250 bu/A in several regions of the U.S. in 1994. When yield limiting factors are removed by management, weather, or both, modern hybrids and varieties have remarkable yielding ability.

Predicting crop response to P is a critical step in designing a management plan to eliminate P as a limiting factor in crop production. Many interacting factors influence the crop response to fertilizer P, requiring an evaluation of the specific conditions of each site. Consider the following points.

## Factors That Influence Phosphorus Responses

**Predicting P response starts with soil testing.** There is no substitute for accurate soil testing. Decades of soil test calibration research go to work for us once soil test levels are known. A very low soil test level means that an economical response will occur more than 80 percent of the time. A very high level means that no response will occur more than 80 percent of the time. Many other factors influence response between the extremes and help determine whether a specific field will go "against the odds" and regularly respond to fertilizer P at a very high soil test level . . . or not respond at a low soil test level.





**Recognize potential within-field soil P variability.** Don't assume that a single sample collected to represent the average level of a field tells the whole story. Recent summaries of data from detailed soil sampling have shown tremendous variability in P. Many fields that average high or very high have substantial areas within the field that test low or even very low.

**Is soil drainage impaired?** Crops on poorly drained soils, such as those in a Minnesota study summarized in **Figure 1**, often show P response even at high soil test levels. Low oxygen availability in poorly drained soils reduces root growth rates and the ability of roots to absorb and translocate P. The higher soil moisture content also tends to keep these soils cooler in the spring, further reducing P uptake. Combine yield monitors show that tiled (drained) fields often have significant areas where yields are reduced due to failing tile lines or laterals spaced too far apart.

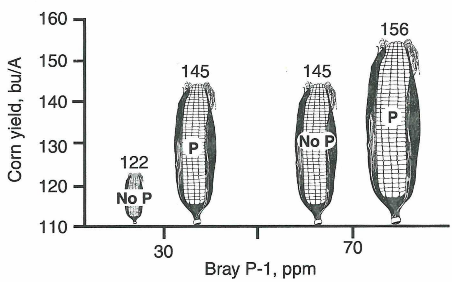



**Figure 1. Starter P increases yields on poorly drained soils even at very high soil test levels. (Minnesota)**

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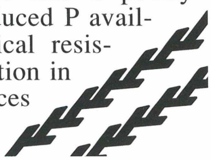
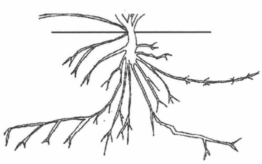
**Compaction can reduce P availability.** Many fields were worked and planted wet last spring. That caused soil compaction which can make a normally well-drained soil act like a poorly drained soil with reduced P availability. Added physical resistance to root penetration in compacted soils reduces the crop's ability to obtain soil P.



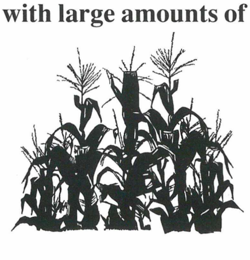
**Phosphorus placement can influence P response.** Band placement will usually outperform broadcast P applications at modest rates and low soil test levels. As soil test level or rate increases, differences generally decrease and often disappear. However, response to starter P banded in or near the seed row can occur even at extremely high soil test P levels.

**Areas of fields that were flooded the year before often have reduced P availability for the following crop.** A combination of soil chemical changes and a reduction in beneficial mychorrizal (fungal) colonization of crop roots contribute to frequent P deficiency in these areas, even at very high soil test levels.



**Varieties and hybrids often differ in P response.** Many studies have shown that crop varieties or hybrids can differ substantially in P response, especially response to banded P. This means that specific crop varieties being grown may not respond the same as those used when P management guidelines were developed. General guidelines require local fine tuning because of potential varietal differences.

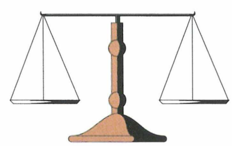
**Tillage systems with large amounts of surface residue usually result in greater response to starter P.** Cool, wet spring soil conditions are at least a part of the cause of the increased starter need. Root development is slowed and generation of energy necessary for nutrient uptake is diminished.



**Salt-affected areas of fields typically show more P response than normal areas.** Plant P uptake and concentrations are often reduced as soil salinity increases. Salts carried in water concentrate in field areas where water tends to flow or wick to the surface and evaporate. Greater P response and higher P needs can be expected in these parts of the field.

**High aluminum (Al) levels in acid soils increase wheat response to P.** Phosphorus banded with the seed lowers the toxicity of Al even when P tests are very high. Lime if you can . . . and be sure plant P needs are met.

**Balanced nutrition is a must for full P response.** Insufficient levels of other nutrients substantially reduce response to P. For example, in one Kansas study on irrigated corn, 10-year average response to annual P applications of 40 lb $P_2O_5$/A varied from 5 to over 50 bu/A depending on N rate applied.



**Conserving the yield potential of the seeds that are planted is a season-long process.** Phosphorus deficiency prior to the 5-leaf stage of corn reduces the potential number of kernels per ear. In high yielding environments, this translates into lower grain yields.

## Summing Up

Understanding P response can help in the development of a site-specific P management plan that allows harvest of a higher percentage of the crop's genetic potential, leading to greater profitability. The plan should focus on soil testing, but consider the multitude of factors that influence P response. A P management plan should be dynamic, evolving each year as more is learned about the unique requirements of the specific soils, crops, and cultural practices employed. ■